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ABSTRACT

Informal and formal mathematical abilities were studied in the preschool, kindergarten, and first grade children in Beijing, China and Chinese-American children in New York City. Test of Early Mathematical Abilities-2nd Edition (TEMA-2) was administered to the three groups of children (children from Beijing, Chinese-American from lower-class, and Chinese-American from middle-class families). A parent questionnaire was also used to examine parents' attitudes toward their children's learning in the early school years and the nature of parent-child interaction at home. Results indicate that with regard to informal mathematical knowledge, preschool children in Beijing outperformed their Chinese-American peers from lower-class families. Chinese-American preschoolers from middle-class families did equally as well as those from Beijing in the overall informal mathematics. At the kindergarten level, children from Beijing outperformed Chinese-American children from both lower- and middle-class families in overall informal mathematics but not in formal mathematics. At the first grade level, a significant difference was found in formal mathematics with children from Beijing performing significantly better than Chinese-American children from both lower- and middle-class families. Responses from the parent questionnaire suggest similarities in terms of values, expectations, and the nature of parent-child interactions among the three groups. Factors that do and do not seem to explain performance differences among the groups are also discussed. Contains 13 references. (Author/NB)

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Understanding Informal and Formal Mathematical Abilities in Mainland Chinese and Chinese-American Children

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SECTION M

Abstract

Informal and formal mathematical abilities were studied in the preschool, kindergarten, and 1st grade children in Beijing, China and Chinese-American children in New York City. Test of Early Mathematical Abilities-2nd Edition (TEMA-2) (Ginsburg & Broody, 1990) was administered to the three groups of children (Children from Beijing, Chinese-American from low-class, and Chinese-American from middle-class families). Parent questionnaire was also used to examine parents' attitudes toward their children's learning in the early school years and the nature of parent-child interaction at home. Results indicated that with regard to informal mathematical knowledge, preschool children in Beijing outperformed Chinese-American peers from lower-class families. Chinese-American preschoolers from middle-class families did equally well as those from Beijing in the overall informal mathematics. At the kindergarten level, children from Beijing outperformed Chinese-American children from both lower- and middle-class families in overall informal mathematics but not in formal mathematics. At the 1st grade level, significant difference was found in formal mathematics with children from Beijing performing significantly better than Chinese-American children from both lower- and middle-class families. Responses from parent questionnaire suggest similarities in terms of value, expectations, and nature of parent-child interaction among the three groups. Factors that do and do not seem to explain performance differences among the groups are also discussed.

Introduction

Research during the past two decades has provided rich information concerning our understanding of how and why children of different nations (particularly Asian countries and the U.S.) vary in the pace and level of mathematical development. Although a large amount of cross-cultural studies have compared Chinese and American children's mathematics performance at various grade levels, there is virtually no study that examines Chinese-American children's mathematical performance in the early years. Therefore, little is known regarding the nature of American-Chinese children's knowledge of early mathematics in comparison to their Chinese counterparts in their home country. Information gained from such comparisons can provide insight into the factors contributing to the differences, if any, in the performance of various Chinese groups. In addition, this information can shed light on our further understanding of the cross-cultural differences between mainland Chinese and American children in their mathematics performance.

The general theme in previous cross-national studies is that the learning gap between Asian (Chinese, Japanese, and Korean) and American children in mathematics appears as early as kindergarten, and U.S. children's performance deteriorates with each successive grade (Stevenson, Chen, & Lee, 1993; Stevenson et al., 1990; Stevenson, Lee, & Stigler, 1986; Stigler, Lee, Lucker, & Stevenson, 1982). In particular, Asian children (mainland Chinese) outperform their American peers on tasks such as abstract counting, object counting of large sets, concrete addition and subtraction, pencil-and-paper addition, and numerical memory span (Geary, Bow-Thomas, Fan, & Siegler, 1993; Ginsburg, Choi, Lopez, Netley, & Chi, 1997; Miller, Smith, Zhu, & Zhang, 1995). Moreover, when solving simple addition problems, Chinese kindergarten and 1st grade children were reported to

use more sophisticated strategies than their American counterparts (Geary, Fan, & Bow-Thomas, 1992). Studies that sought to compare the cognitive abilities of Japanese, Chinese, and American elementary school children indicated that cross-national achievement differences are often associated with no difference in basic cognitive ability (Stevenson et al., 1985; Stevenson et al., 1993). To explain Asian's superior mathematics achievement, one body of research on motivational explanations focused on parents' high expectations of their children, and parents' beliefs in the importance of effort rather than inherent ability in academic achievement (Stevenson, Lummis, Lee, & Stigler, 1990). Others have focused on the role of schools. For example, Stigler and Perry (1988) demonstrated that Asian teachers tend to explain mathematics in more depth and place a greater stress on thinking and understanding than American teachers. In comparison, the "unfocused mathematics curriculum" characterizes the U.S. approach.

The impact of the experiences that young children have at home and school on the development of their early mathematical thinking has not been explored extensively. In one study, Ginsburg et al., (1997) compared the performance of kindergarten children in mainland China with instruction and those without instruction. The former scored at a higher level than children from other countries (e.g., Columbia, Japan, Korea, and the U.S.) on several tasks measuring informal mathematics (e.g., counting, perception of more, concrete subtraction and addition, informal subtraction and addition, etc.). Chinese children without instruction performed at about the same level as several other U.S. groups (e.g., American white, African Americans, and Korean Americans). Zhou, Peverly, Boehm, and Lin (1998) showed that the instruction emphasizing both conceptual and procedural knowledge accelerated elementary (3rd grade) Chinese children's development of basic mathematical concepts, such as distance, time, and speed. In sum, previous

research shows that planned, purposeful activities will facilitate and accelerate young children's understanding of early mathematical concepts.

The present study has three purposes. First, the performance of children from Beijing, Chinese-American from lower-class families, and Chinese-American from middle-class families in a variety of areas of informal mathematics (e.g., relative magnitude, counting, and calculation) is compared. The following questions are asked: a) Do the three groups differ in informal mathematics? b) What is the nature of this difference, if any, in the informal mathematics performance among the three groups?

Second, the difference in children's learning of formal mathematics (e.g., convention, number facts, calculation, and base-10) is examined. The following questions are explored: a) Is there any difference in performance among native Chinese, Chinese–American from lower-class families, and Chinese-American from middle-class families in formal mathematics? b) What is the nature of this difference, if any, in understanding formal mathematics?

Third, parental attitude toward learning and teaching in early years as well as activities at home and school are explored. The following questions are asked: a) Do the groups differ with respects to their home environment (e.g., parents' level of education, and parental involvement in their children's learning and play)? b) What do parents regard as the most important things for their children to learn during early years of schooling? What are the characteristics of a good teacher? c) Are there any differences in parents' involvement in their children's learning and play? If so, how do the activities differ? How do school environment differ in promoting young children's mathematics learning?

This information can further our understanding in terms of the roles of home and school environment in facilitating and accelerating young children's development of early mathematics concepts.

Method

Participants

A total of 270 children participated in this study with 90 children at each age level (preschool, kindergarten, and 1st grade) from each group (Chinese in Beijing, American-Chinese from lower-class families, and American-Chinese from middle-class families). Beijing children were sampled from two elementary schools serving average-income families. These two schools were not "key" schools where much higher admission standards were held. The Chinese-American preschool children were sampled from daycare centers serving low-income families in New York City Chinatown. Lastly, Chinese-American kindergarten and 1st grade children were sampled from New York City public schools.

Measures

Test of Early Mathematics Ability-Second Edition (TEMA-2) (Ginsburg & Broody, 1990) will be administered to children. This measure consists of 65 items that measure children's early mathematical thinking. TEMA-2 contains 35 items that measure informal mathematics which include three types of subskills: a) concepts of relative magnitude, such as judging relative size of spoken numbers and distance between numbers on a mental number line; b) counting, such as basic counting sequence, counting by twos, counting backwards, and completing a given counting sequence; and c) calculation, which includes addition of concrete objects and mental addition and subtraction. There are 30 items in the formal mathematics category, where four types of subskills are measured: a) knowledge of convention,

such as basic skills of reading and writing numerals; b) number facts, such as solving simple addition, subtraction and multiplication problems with speed and accuracy; c) calculation, such as written addition and subtraction with emphases on both accuracy and strategy; and d) base-10 concepts, such as understanding of money with different values and solving addition and subtraction problems involving multiples of 10. Chinese-American children were tested with the English or the Chinese version of the TEMA-2, depending on their language proficiency.

Questionnaires were distributed to the parents of the children involved in this project. They were asked to list three most important activities that their children should learn in preschool, kindergarten, and 1st grade. In addition, parents were asked to provide information concerning the types of activities in which they engaged with their children at home and the amount of time they usually spent with them on those activities. Finally, time-sampling technique was employed to record classroom activities for each of the three groups.

Procedure

Children were individually assessed following the standardized testing procedure described in the TEMA-2 manual. Items were presented in order of increasing difficulty. Testing was stopped when a child made five consecutive errors.

In addition, children in each age level were observed in their classes in order for us to explore how children's learning environment impacted on their development of early mathematics abilities.

Results

Cultural differences in informal mathematics achievement—A three-way ANOVA by group, grade, and gender was performed on the overall informal

mathematics. Results revealed significant main effects of group and grade. Post hoc analyses using the Bonferroni test indicated that at the preschool level, children in Beijing performed significantly better than Chinese-American peers from lower-class families. However, the performance between Beijing children and Chinese-American from middle-class families did not differ. At the kindergarten level, children in Beijing did significantly better than Chinese-American children from both lower- and middle-class families. The difference between two Chinese-American groups, however, did not differ. Lastly, children's informal knowledge did not differ among the three groups at the 1st grade level.

Cultural differences in formal mathematics achievement—A three-way ANOVA by group, grade, and gender was performed on the overall formal mathematics. Results revealed significant main effects of group and grade. Post hoc analyses using the Bonferroni test indicated that at both preschool and kindergarten levels, there was no significant difference among the three groups. However, at the 1st grade, Beijing children demonstrated significantly superior performance over Chinese-American children from both lower- and middle-class families.

Parent-child interaction--Information obtained from the parent questionnaires indicated that "getting along with peers," "being independent," and "building moral characters" are perceived as the most important things for children to learn during early years of schooling by Beijing parents. For Chinese-American middle-class parents, "getting along with peers" and "being independent" are also considered as the most important activities for young children. They considered "English language skills" to be equally important as well. To the parents of lower-class families, "basic learning" (i.e., reading writing and math), "communication skills," and "mastery of English language" are perceived as the most important things for their young children to learn. Examining the nature of parent-child

interaction among three Chinese groups indicated that "reading and story-telling," "outdoor play and sports," and "games" (e.g., chess, puzzles) are the three most frequent activities in which the Beijing parents and middle-class Chinese-American parents engaged with their children. For the parents of lower-class Chinese-American children, "intellectual games," "basic learning," and "reading" were the most frequently mentioned activities at home. For all three Chinese groups, parents spent about 2 to 3 hours daily on average interacting with their children. With regard to parent's educational level, the majority of Beijing parents and about half of the Chinese-American parents from middle-class families had a college degree. In comparison, Chinese-American parents from lower-class families were predominantly high school graduates.

School experiences--Information from classroom observation showed that preschool and kindergarten children in all three groups frequently engaged in more play-like exploratory activities rather than formal instruction. However, it was apparent that the activities in Beijing preschool and kindergarten classrooms were more organized and purposeful toward helping young children develop basic concepts (e.g., class-inclusion, number and quantity, geometric designs) than those found in Chinese-American classrooms. More specifically, children had to think carefully in order to follow the rules of the game. In 1st grade mathematics classrooms, teachers of Chinese-American children relied on more manipulatives in teaching concepts. In contrast, manipulatives were used less frequently and more emphasis was placed on building abstract reasoning skills in Beijing classrooms. In Chinese-American children's classrooms, more small-groups activities with little teacher-guidance were also observed, whereas in Beijing schools, focused class-instruction took up the most class time. Moreover, the lessons were more coherent

and children's thinking were often challenged throughout the class period in Beijing schools.

Conclusions

The results of the present study clearly show that by the 1st grade the performance level of Beijing children significantly surpasses that of Chinese-American children from both lower- and middle-class families in formal mathematics. Due to the lack of comparative studies on Chinese-American children's early mathematics abilities, we are unable to find any data in the current literature to support our findings. However, our results are generally consistent with the previous findings that by 1st grade, Chinese children in mainland performed significantly better than their American peers in solving addition and subtraction problems (Geary, Liu, & Bow-Thomas, 1992).

Several factors do not seem to explain the Beijing children's better performance. First, parents of the three Chinese groups all have high expectations of their children. Previous cross-cultural studies indicated that parents of mainland Chinese children hold higher expectations of their children. It is also known that the parents of Chinese-American children often sacrificed their own careers when they immigrated to this country so that their children could have a better education and life in US. Second, language does not seem to be a factor. In previous comparative studies language differences were considered as a contributing factor to Chinese children's superior mathematics performance over their American peers (Miller et al., 1995). In the present study, nearly all Chinese-American children are Chinese language dominant. They speak Chinese at home with their parents and grandparents. For some children, instructions had to be given in Chinese. During early years, Chinese parents and grandparents often read to and do mathematics with their children in the native language. Third, the parental perception of what

was important for their children to learn was very similar for both Beijing and Chinese-American middle-class families: independence and social skills were emphasized. For the parents of Chinese-American of lower-class families, basic skills (e.g., reading and math) were perceived as the most important. Fourth, the nature of parent-child interaction was almost identical among the three Chinese groups: reading, intellectual games, and outdoor activities. Fifth, the amount of time that the parents spent with their children was about 2 to 3 hours on average for all families.

With regard to the informal mathematics knowledge, although Beijing children demonstrated an initial advantage over the Chinese-American children in kindergarten, such superiority disappeared in the first grade. Therefore, Beijing children's superior performance in school mathematics cannot be explained by a head start in informal mathematics.

Why do Beijing children perform so well? The reasons seem to involve environmental factors in the school setting. First, the amount of time devoted to mathematics instruction is greater in China than in the United States (Stevenson et al., 1986). Second, Chinese teachers are knowledgeable in the field they are teaching. It is very common for Chinese teachers to receive in-service teacher training which encourages Chinese teachers to maintain and improve their knowledge and instructional strategies in mathematics education. Third, for the past decade, early childhood mathematics educators have placed great emphasis on teaching mathematics for understanding. Unlike the traditional method which focuses heavily on rote memory and drills in mathematics learning, the mathematics reform stresses four elements: flexible thinking, in-depth processing of mathematics information, critical thinking, and speed. Chinese teachers are trained to provide instructions that promote the development of these elements.

Fourth, the curriculum that has been developed for preschool, kindergarten, and early elementary school children is based on empirical research. The curriculum reflects "the goodness of fit" between children's cognitive readiness and the mathematics knowledge structure.

In conclusion, Mainland Chinese children's superior performance seems to be contributed by an efficient educational system, well-designed curriculum, and knowledgeable and dedicated teachers. Future studies should explore acculturation issues which may also impact on Chinese-American children's less adequate mathematics achievement in comparison to their Chinese peers in their home country.

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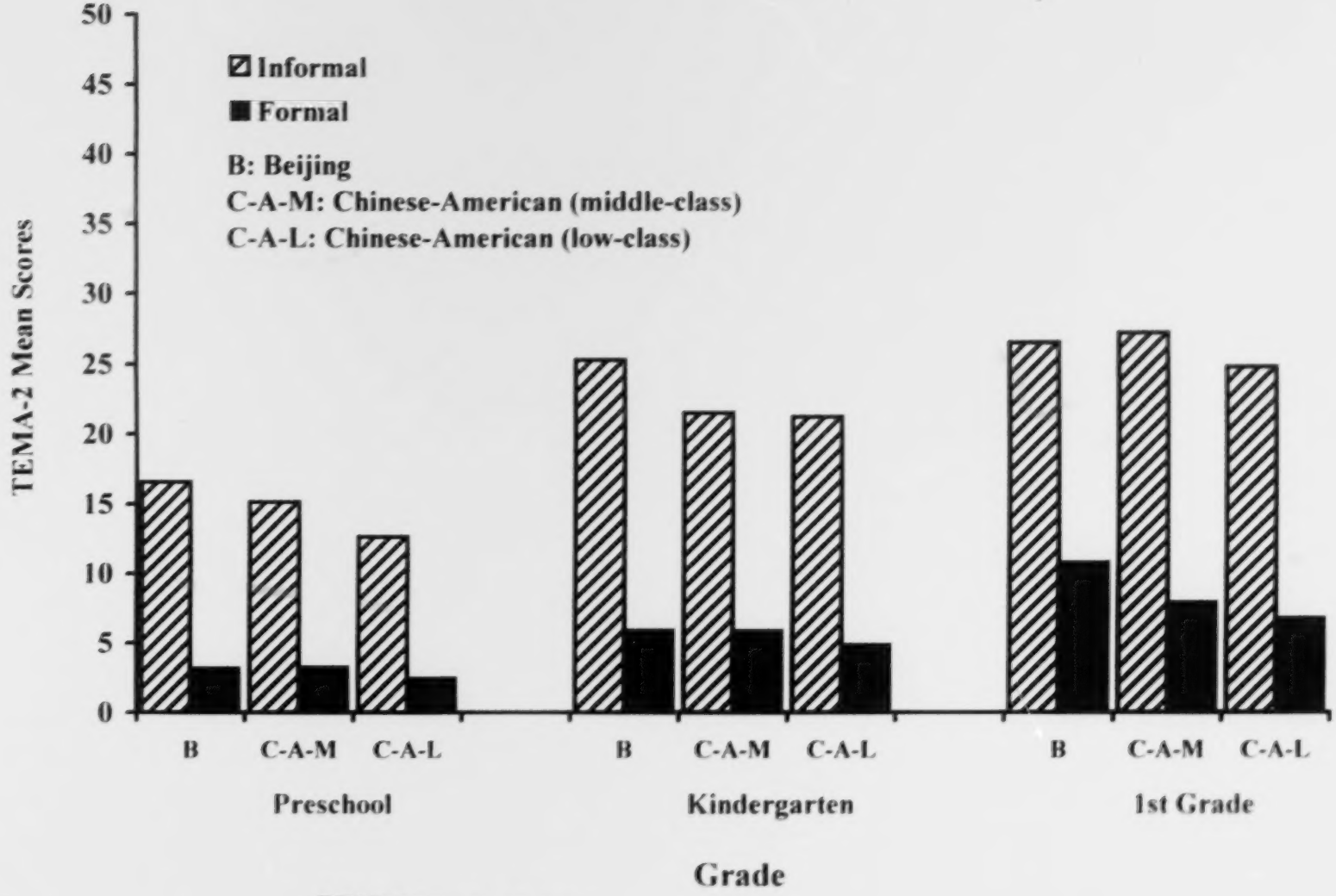
Mean Scores in Informal and Formal Mathematics by Grade and Ethnicity



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